details of the amendment):

--A method of forming a magnetic resonance image involves separate measurement of the position of a measuring site. The magnetic resonance image is corrected on the basis of the measured position of the measuring site.--

A1

<u>IN THE SPECIFICATION</u>:

Please amend the specification as follows (see the attachment for details of the amendment):

Please amend the paragraphs at page 2, lines 5 to 23 as follows:

--In accordance with the invention, the position of a measuring site is separately determined, such a position can be separately measured. Furthermore, a predetermined geometrical relationship exists between the measuring site and the region reproduced in the magnetic resonance image. On the basis of the position determined for the measuring site, disturbances due to motion of the object to be examined can be avoided in the magnetic resonance image on the basis of the predetermined geometrical relationship between the measuring site and the region to be imaged. The object to be examined is a patient. During the acquisition of the magnetic resonance signals, the patient is liable to move and/or motions are liable to occur within the body of the patient, due to the respiration and/or the

A2 Cont'd

heartbeat. The magnetic resonance imaging method according to the invention notably ensures that hardly any disturbances which are due to such motions in and/or of the patient occur in the magnetic resonance image.

A2 end

The invention is implemented in such a manner that a selected slice of the object to be imaged contains the measuring site. Notably when images of the same slice are repeatedly formed it is achieved that the same slice is always accurately reproduced. It is then ensured that the selected slice always extends through the measuring site. The selection of such a slice is performed on the basis of an RF excitation in combination with a selection gradient. Such a selection gradient is superposed on the steady magnetic field.--

Please amend the paragraph at page 2, line 33 to page 3, line 7 as follows:

A3 cont'd

--Preferably, a clearly recognizable detail of the object to be examined and an indication of the measuring site are reproduced in the magnetic resonance image. This is realized by reproducing the relevant detail and the measuring site together in the magnetic resonance image. On the basis of the predetermined geometrical relationship between the measuring site and the relevant detail, the correct position of the reproduction of the detail relative to the indication of the measuring site in

the magnetic resonance image can also be derived. On the basis of the derived correct position of the detail it can then be readily checked whether the position of the detail has shifted due to motion in and/or of the object and, if desired, the position of the detail in the magnetic resonance image can be corrected.--

A3 end

Please amend the paragraphs at page 5, line 11 to page 7, line 8 as follows:

--Preferably, a set of reference magnetic resonance signals is acquired at a predetermined reference temperature. When the local temperature within the body of the patient to be examined is derived by means of the method according to the invention, the reference temperature is the body temperature of the patient to be examined. Subsequently, the temperature is locally increased and a set of reference magnetic resonance signals is acquired at the increased temperature. Because the position of the measuring site has been separately measured, the temperature dependent chemical shift can be derived from the frequency shift of the measuring magnetic resonance signals relative to the reference magnetic resonance signals, so that the local temperature can be determined at the measuring site. Because the position of the measuring site has been separately measured, the accuracy of the determination of the temperature will hardly be affected when motion of and/or in the patient to be examined occurs between the

A4 cont'd

acquisition of the reference magnetic resonance signals and the measuring magnetic resonance signals. Furthermore, the position of the measuring site at which the local temperature increase is measured is particularly reliable and notably is hardly affected by motions of and/or in the patient to be examined.

Further advantages are achieved by deriving the temperature distribution in the object to be examined on the basis of the measuring magnetic resonance signals, the reference magnetic resonance signals and the position of the measuring site determined. Preferably, this temperature distribution is reproduced as a thermal image. Brightness or color values represent the local temperature in such a thermal image. Furthermore, such a thermal image also contains image information concerning the anatomy of the patient. This image information is acquired by means of magnetic resonance imaging methods which are known per se. Such a temperature distribution constitutes a useful technical aid notably for performing thermal treatment on the body of the patient. Such thermal treatments concern (laser) ablation of tissue. Laser radiation is then used to destroy diseased tissue by local heating. The diseased tissue in the desired region can be readily locally thermally treated on the basis of the temperature distribution reproduced in the thermal image.

A4 Contd

It has been found that a microcoil is particularly suitable for determining the position of the measuring site. The microcoil is introduced into the body of the patient. The microcoil receives magnetic resonance signals practically exclusively from the immediate vicinity of the microcoil. The magnetic resonance signals received by the microcoil thus accurately represent the current position of the microcoil. The location where the microcoil is situated thus constitutes the measuring site. Microcoils for interventional e.g. endocavitary applications are smaller than approximately 1 cm. Generally speaking, microcoils having dimensions of between 0.5 mm and 3 mm are used, but even smaller microcoils, being smaller than 1 mm or even as small as approximately 0.1 mm, are also used to determine the position of the measuring site particularly accurately. The microcoil is preferably used in conjunction with an energy-dissipating element. Such an energy-dissipating element locally deposits energy in the form of laser radiation, in the tissue so as to increase the local temperature. The microcoil is preferably arranged near the energy-dissipating element. Furthermore, the microcoil is advantageously used in combination with a temperature sensor. Use is preferably made of a temperature sensor in the form of a fiber thermometer. Such a fiber thermometer has hardly any disturbing effect on the magnetic resonance signals. Preferably, the temperature sensor is arranged

A4 Cont'd

in the immediate vicinity of the microcoil. This enables separate measurement of the temperature in the direct vicinity of the microcoil. The temperature distribution relative to the temperature measured at the measuring site can be derived on the basis of the position of the measuring site as determined by the microcoil and the temperature at the measuring site as determined by the temperature sensor.

a4 cont'd

The invention also relates to a magnetic resonance imaging system. The magnetic resonance imaging system according to the invention is arranged to determine the position of the measuring site. Preferably, the magnetic resonance imaging system according to the invention is provided with the microcoil. Using the microcoil, magnetic resonance signals representing the position of the measuring site are acquired at the area of the measuring site or in the immediate vicinity of the measuring site. Such a microcoil enables measurement of the position of the measuring site with an accuracy of less than 1 mm and even 0.1 mm. This accuracy is dependent inter alia on the accuracy of measurement of the temperature and the phase of the position magnetic resonance signals. It is also advantageous to use a plurality of microcoils, preferably two or three microcoils. When two microcoils are used, the position and the direction of the line through the microcoils can be measured; when three microcoils are used (not in one line), the position and the orientation of the

plane through the three microcoils can be measured. It is also possible to use an even larger number of microcoils in order to measure deformations in the anatomy of the patient. The magnetic resonance image can be corrected for the measured deformation by image processing on the basis of the measured deformations. --

A4 end

Please amend the paragraphs at page 7, line 25 to page 9, line 3 as follows:

--Fig. 1 shows diagrammatically a magnetic resonance imaging system in which the invention is used. The magnetic resonance imaging system includes a set of main coils 10 for generating the steady, uniform magnetic field. The main coils are constructed in such a manner that they enclose a tunnel-like examination space. The patient to be examined is slid into said tunnel-like examination space. Furthermore, the magnetic resonance imaging system includes a number of gradient coils 11, 12 whereby spatially varying magnetic fields, notably in the form of temporary gradients in different directions, are superposed on the uniform magnetic field. The gradient coils 11, 12 are connected to a variable power supply unit 21. The gradient coils 11, 12 are energized by applying an electrical current thereto by means of the power supply unit 21. The strength, the direction and the duration of the gradients are controlled by control of the power supply unit. The magnetic resonance imaging system also

A5 cont'd

includes transmission and receiving coils 13, 15 for generating the RF excitation pulses and for picking up the magnetic resonance signals, respectively. The transmission coil 13 is preferably constructed as a body coil 13 which is arranged to enclose (a part of) the object to be examined. The body coil is usually mounted in the magnetic resonance imaging system in such a manner that the patient 30 to be examined, being positioned inside the magnetic resonance imaging system, is situated within the body coil 13. The body coil 13 acts as a transmission antenna for the transmission of the RF excitation pulses and RF refocusing pulses. Preferably, the RF pulses transmitted by the body coil 13 have a spatially uniform intensity distribution. The same coil or antenna is usually used alternately as a transmission coil and as a receiving coil. Furthermore, the transmission and receiving coil is usually shaped as a coil, but other geometries where the transmission and receiving coil serves as a transmission and receiving antenna for RF electromagnetic signals are also feasible. The transmission and receiving coil 13 is connected to an electronic transmission/receiving circuit 15.

A5 Cont'd

It is to be noted, however, that separate receiving coils may alternatively be used. Receiving coils in the form of surface coils may be used. Such surface coils have a high sensitivity in a comparatively small volume. The transmission coils, such as the surface coils, are connected to a demodulator 24 and the magnetic

resonance signals (RFS) received are demodulated by means of the demodulator 24. The demodulated magnetic resonance signals (DMS) are applied to a reconstruction unit. The receiving coil is connected to a preamplifier 23. The preamplifier 23 amplifies the RF resonance signal (RFS) received by the receiving coil and the amplified RF resonance signal is applied to a demodulator 24. The demodulator 24 demodulates the amplified RF resonance signal. The demodulated resonance signal contains the actual information concerning the local spin densities in the part of the object to be imaged. Furthermore, the transmission and receiving circuit 15 is connected to a modulator 22. The modulator 22 and the transmission and receiving circuit 15 activate the transmission coil 13 so as to transmit the RF excitation and refocusing pulses. The reconstruction unit derives one or more image signals, representing the image information of the imaged part of the object to be examined, from the demodulated magnetic resonance signals (DMS). In practice the reconstruction unit 25 is preferably constructed as a digital image processing unit 25 which is programmed to derive from the demodulated magnetic resonance signals the image signals which represent the image information of the part of the object to be imaged. The signal on the output of the reconstruction unit is applied to a monitor 26 so as to display the three-dimensional density distribution or the spectroscopic information on the monitor. It is alternatively

a5
Cont'd

A5 end

possible to store the signal from the reconstruction unit in a buffer unit 27 while awaiting further processing.--

Please amend the paragraphs at page 9, line 17 to page 10, line 25 as follows:

--Furthermore, the interventional instrument includes a temperature sensor 42 for measurement of the local temperature. The interventional instrument is, for example, also provided with a so-called "cryoprobe" 43 whereby tissue can be locally and temporarily cooled. Liquid helium can be locally applied. Instead of, or in addition to, a cryoprobe it is also possible, for example, to provide the interventional instrument with an optical fiber 45, one end 44 is situated in the immediate vicinity of the microcoil 40. The other end of the optical fiber can be connected to a laser 46. The laser light which then emanates from the end 44 of the optical fiber 45 and enters the patient locally warms up or even heats tissue. An RF ablation probe can also be used to heat tissue. The cryoprobe 43 and/or the laser 46 are controlled by means of an intervention control system 50. The reconstruction unit 25 reconstructs the temperature distribution and/or the variations thereof in the form of one or more thermal images on the basis of the temperature measured by means of the temperature sensor 42, the position magnetic resonance signals (so the position determined for the measuring site) and the demodulated

A6 cont'd

magnetic resonance signals.

Fig. 2 shows graphically a sequence of RF pulses and gradient pulses which are used to carry out the invention. Graph (a) shows the sequences of RF excitation pulses (EX1, ..., EXi), refocusing pulses (RF1, RF2, RF3, ..., RFi), read-out gradients (RG1, RG2, ...) and the magnetic resonance signals (gradient echoes) (RFS11, RFS12, RFS13, RFS21, RFS22, RFS23, ...) generated thereby. Graph (b) shows the associated phase encoding gradients. The sequence shown is a so-called GRASE sequence in which a plurality of RF refocusing pulses are applied between individual RF excitation pulses. The RF excitation pulses excite spins in the body of the patient to be examined. The RF excitation pulse excite spins in a selected slice of the body of the patient. Such a slice is selected by superposition of a selection gradient on the steady magnetic field of the main coils. The refocusing pulses generate spin echoes from the excited spins. A plurality of temporary, successive read-out gradients RG11, RG12, ..., RG23 are applied between successive RF refocusing pulses. The read-out gradients generate the gradient echoes of the excited spins. The combination of the RF refocusing pulses and the read-out gradients yields magnetic resonance signals RFS. Such magnetic resonance signals have the mixed character of spin echo signals and gradient echo signals. Phase-encoding gradients are applied between the successive read-out gradients RG11, ..., RG23. The

A6 cont'd

direction of the phase-encoding gradients extends essentially perpendicularly to the direction of the read-out gradients. Under the influence of the read-out gradients as shown in the graph (b) in Fig. 2, the wave vector of the magnetic resonance signals describes parallel, mutually offset line segments in the k space. The phase-encoding gradients ensure that path between successive refocusing pulses a part of the k space is traversed each time along a meandering path. The line segments constitute respective straight parts of the meandering path. The successive meandering paths between successive pairs of refocusing pulses are mutually offset in the k space. In the example shown in Fig. 2 a first meandering path in the k space which is described by followed by the magnetic resonance signals RFS11, RFS12 and RFS13 and the meandering path through the k space which is desired by the magnetic resonance signals RFS21, RFS22, RFS23 has been shifted in the direction transversely of the direction of the straight segments of the meandering path.--

A6 end

IN THE CLAIMS:

Please amend claims 1 to 12 and add new claims 13-17 as follows (see the attachment for details of the amendment):

A7 Sub B1 cont'd

1. (Amended) ~~A~~ method of forming a magnetic resonance image of a region to ~~be~~ imaged comprising the steps of: